Claims

1. Process for the preparation of an electrode for an electrochemical system from a porous material.

2. Process for the preparation of an electrode according to claim 1 in which the porosity of said porous material, measured by the mercury method, varies from 1 to 99%, terminals included.

3. Process for the preparation of an electrode according to claim 2 in which the porosity of said material varies from 20 to 80%, terminals included.

4. Process for the preparation of an electrode according to any one of claims 1 to 3 in which the average size of the pores in said porous material varies from 1 nanometer to 1 micrometer, terminals included.

5. Process for the preparation of an electrode according to claim 4 in which the size of the pores varies from 10 to 250 nanometers, terminals included.

6. Process for the preparation of an electrode according to any one of claims 1 to 5 in which the distribution of the pores is substantially uniform, preferably, the distribution of the pores is such that its d50 is between 100 and 150 nanometers.

7. Process for the preparation of an electrode according to any one of claims 1 to 6 in which the pores are located at the surface of the

porous material and extend throughout said porous material; preferably the pores have a depth between 1 micrometer and 3 millimeters and said porous material has a thickness between 2 micrometers and 3.5 millimeters.

8. Process for the preparation of an electrode according to claim 7 in which said pores do not extend entirely throughout the porous material.

9. Process for the preparation of an electrode according to any one of claims 1 to 8 in which said porous material is capable of forming an alloy with an alkali metal.

10. Process for the preparation of an electrode, according to any one of claims 1 to 9 in which the porous material is selected from the group consisting of silicon, tin, aluminum, silver, gold, platinum and mixtures of at least two of these materials when they are in porous form.

11. Process for the preparation of an electrode, according to claim 9 or 10 in which the preparation of the alloy is carried out by chemical and/or electrochemical means.

12. Process for the preparation of an electrode according to claim 11 in which the void ratio of the material used to form the electrode is such that the cavities of the porous material can absorb the voluminal expansion generated during formation of the alloy with the alkali metal.

13. Process for the preparation of an electrode that is an anode, according to any one of claims 1 to 12 in which the porous material is porous silicon.

14. Process for the preparation of an anode according to claim 13 in which said anode is obtained by formation of an alloy from at least one source of porous silicon and at least one alkali metal selected from the group consisting of Li, Na, Ca and mixtures of at least two of these metals.

15. Process for the preparation of an anode, according to claim 14 in which the anode is based on porous silicon, wherein the porosity, measured according to the porosimeter mercury method, varies from 5 to 95 volume %, terminals included.

16. Process for the preparation of an anode, according to claim 15 in which the porosity is about 75 volume %.

17. Process for the preparation of an anode, according to any one of claims 14 to 16 in which the porous silicon used as porous material is obtained from a source of silicon selected from the group consisting of: silicon wafers, silicon pellets, silicon films and mixtures of at least 2 thereof.

18. Process for the preparation of an anode according to any one of claims 14 to 17 in which the porous silicon used as porous material is obtained from a silicon monocrystal.

19. Process for the preparation of an anode, according to any one of claims 13 to 18 in which the porous silicon is obtained from a

source of silicon, by electrochemical treatment, in a bath comprising at least one salt, said salt preferably being selected from the group consisting of NH_XF_Y wherein X is 4 or 5 and Y is 1 or 2, more preferably still the selected salt is NH_4F.

20. Process for the preparation of an anode according to claim 19 in which the bath used for treating the source of silicon contains at least one salt in solution, that is preferably a mixture of H_2SO_4, NH_4F and H_2O, and at least one non aqueous solvent that is preferably an alcohol or a ketone, the non aqueous solvent(s) being preferably selected from the group consisting of methanol, ethanol, acetone and mixtures of at least 2 of these solvents.

21. Process for the preparation of an anode according to claim 20 in which the bath contains, in volume, from:

- 10 to 60% NH_4F;
- 5 to 20% methanol; and
- 75 to 20% H_2SO_4.

22. Process for the preparation of an anode according to any one of claims 14 to 21 in which the porous silicon based alloy is in the form of Si_xLi_y, wherein x represents a number between 1 and 5, and y represents a number between 5 and 21.

23. Process for the preparation of an anode according to claim 22 in which x represents about 4 and y represents about 21.

24. Process for the preparation of an anode according to any one of claims 19 to 23 in which the alloy formed is of the Si_xLi_y type, and

it is obtained by electrochemical means by contacting a source of silicon with lithium and/or metallic lithium in the form of sheets or wafers, at a temperature between 40 and 100° Celsius, preferably at a temperature of about 80° Celsius.

25. Process for the preparation of an anode according to claim 24 in which the time of contact between the source of silicon and metallic lithium is between 1 and 12 hours, preferably said time is about 3 hours.

26. Anode obtained by implementing a process according to any one of claims 1 to 25.

27. Anode characterized in that it contains at least 60 weight % and preferably at least 40% of a porous material, preferably porous silicon.

28. Anode according to claim 27, at least partly coated with carbon.

29. Anode according to claim 27 or 28, substantially free of cracks.

30. Electrochemical system including at least one anode as defined in any one of claims 26 to 29, at least one cathode and at least one electrolyte.

31. Electrochemical system in the form of a battery according to claim 30, in which the electrolyte is of the liquid, gel, or polymer type.

32. Electrochemical system according to claim 31 that is a battery in which the cathode is of the type $LiCoO_2$, $LiFePO_4$, $LiNiO_2$, $LiNi_{0.5}Mn_{0.5}O_2$, $LiNi_{0.33}Mn_{0.33}O_2$, and the cathode is preferably of the 1 to 5 Volts type.

33. Battery according to claim 32 of the rechargeable type, preferably of the lithium ion type.

34. Battery according to claim 33 in the form of micro-battery, preferably having dimensions between 1 mm^2 and 10cm^2, and which has at least one of the following electrochemical properties:

- electrochemical performances:
  - an electrochemical capacity higher than 1 μWh;
  - a capacity of cycling higher than 500, preferably higher than 1000 cycles;
  - a self-discharge rate lower than 5%, preferably lower than 4%, more preferably still lower than 3%; and
  - a life span, according to the storage test carried out under ambient conditions, higher than 3 years, preferably higher than 5 years.

35. Use of an anode according to any one of claims 26 to 29 in an electrochemical system.

36. Use according to claim 33 as negative electrode for lithium micro-batteries.

37. Process for manufacturing a porous silicon based electrode that is at least partly coated with carbon by thermal pyrolysis of a layer of polymer that is preferably coated in thin layer on a preferably insulating support of porous silicon such as Si_3N_4, pyrolysis of the polymer being preferably carried out at a temperature between 600 and 1100° C and preferably for a period of time between 30 minutes and 3 hours.

38. Process for manufacturing a porous silicon based electrode that is at least partly coated with carbon, by laser pyrolysis of a layer of polymer preferably coated in thin layer on a silicon (insulating) support, the laser beam preferably having an intensity between 10 and 100 milliwatts and being preferably placed at a distance of between 0.5 micrometers and 1 millimeter from the silicon support, preferably during a period of time between 1 second and one minute.

39. Process according to claim 37 or 38 in which the silicon support consists of a silicon monocrystal and it has a thickness of between 100 microns and 3 millimeters.

40. Electrode obtained by implementing one of the processes defined in any one of claims 36 to 39.

41. Electrochemical system including at least one electrode according to claim 40.

42. Process for the preparation of an electrode according to any one of claims 1 to 13 that is a cathode prepared from one target of cathode material, preferably said target is selected from the group consisting of $LiCoO_2$, $LiMn_2O_4$, $LiMn_{1/3}Ni_{1/3}Co_{1/3}O_2$, $LiMn_{½}Ni_{½}O_2$, $LiMPO_4$ (M=Fe, Co, Ni, Mn) and mixtures of at least two thereof, preferably the target material is pressed, the laser is applied on the target at capacities that can vary from 20mW to 2W to produce the porous material that constitutes the cathode that is thereafter stripped from the target with a laser and deposited on a porous Si/carbon/electrolyte half-battery.

43. Process for the preparation of an electrode according to any one of claims 1 to 13 that is a cathode prepared from a compound is paste form made of a mixture of a cathode powder with a carrier solution, preferably toluene, heptane or a mixture of at least 2 thereof; the pasty solution is coated on a plate support (preferably made of glass) placed 100μm from the substrate, preferably silicon; the UV radiation laser beam is applied through the plate support and the cathode is projected on the substrate by pyrolysis.